Model-Observation "Data Cubes" for the DOE Atmospheric Radiation Measurement Facility's LES ARM Symbiotic Simulation and Observation (LASSO) Workflow

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Summary

- LASSO is being developed to provide routine large-eddy simulations (LESs) at the DOE Atmospheric Radiation Measurement (ARM) Facility sites to complement its extensive observations (see Gustafson poster A21D-0161).
- The "data cube" described here is a unified package containing observations, model output, and model metrics for easy access and open use by the research community.

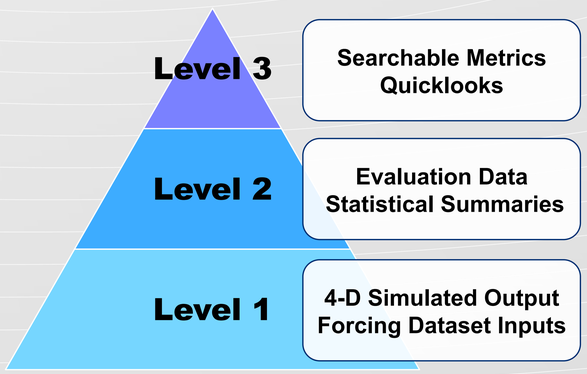
1. What's a Data Cube?

It's a package of LES output and observations aimed at providing the best description of the atmospheric state for analysis.

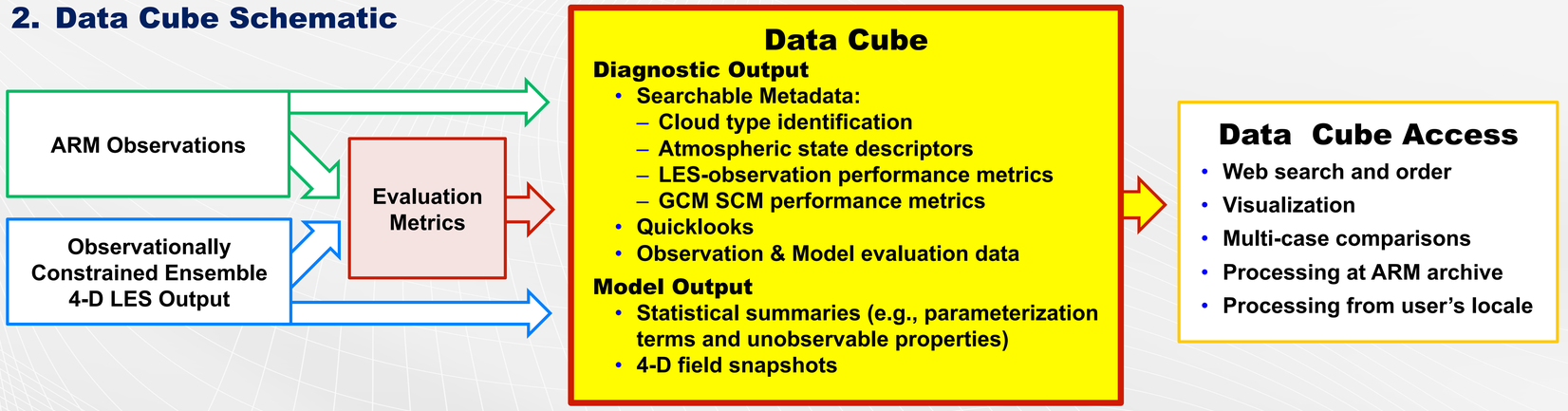
- LES are run using ensemble forcings constrained by ARM observations to generate dynamically consistent pictures of the atmosphere.
- Statistical comparisons of model output with ARM observations are used to assess the quality of a simulation and its uncertainties.

A data cube contains three levels of data (see pyramid) where level 3 is the most processed and easiest to analyze. The levels include:

1. Snapshots of the 4-D simulated fields from the integration period;
2. Statistical summaries of additional model property output that cannot be or are very difficult to observe; and
3. Metrics of model-observation statistical summaries to assess the simulations and the ensemble spread.



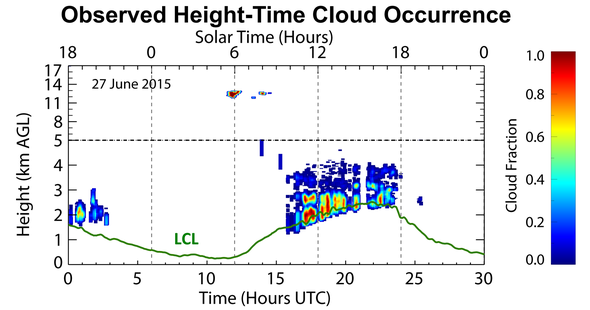
2. Data Cube Schematic



3. Evaluation Diagnostics and Metrics

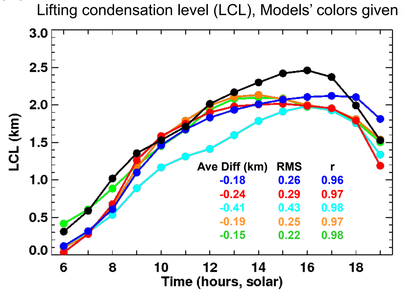
Ensemble large-eddy simulations are assessed using ARM observations of cloud and environmental variables in a series of evaluation diagnostics and metrics including:

a) Time series, with average difference, RMS and correlation coefficient
b) Heat maps, for differences of the simulated time series from observations
c) Regression analysis, for slope and intercept
d) Taylor diagrams (Taylor, 2001), for standard deviation and correlation phase space
e) Phase space relationships, for relative relationships between a set of variables
f) Relative Euclidean distance (Wu et al., 2012), for overall model performance of a variable



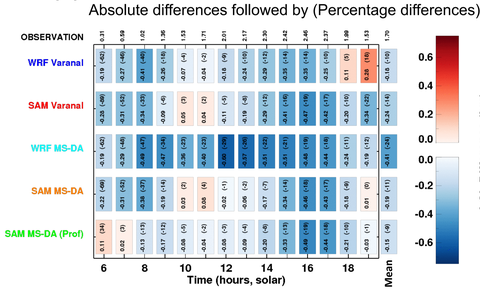
(a) Time series

Lifting condensation level (LCL), Models' colors given in (b).

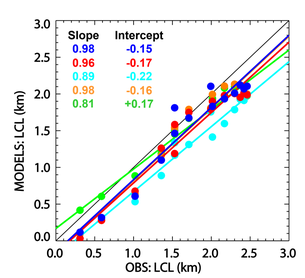


(b) Heat maps

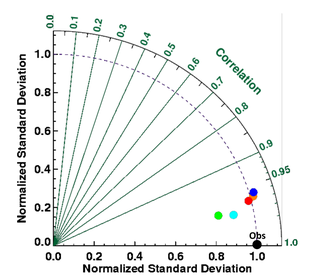
Absolute differences followed by (Percentage differences).



(c) Regressions

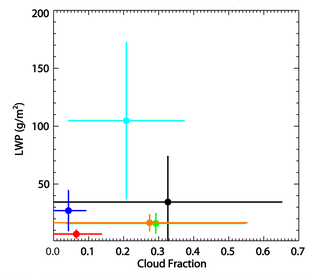


(d) Taylor Diagrams



(e) Phase Space Relationships

AERI/MWR Liquid water path (LWP) and ARSCL cloud fraction

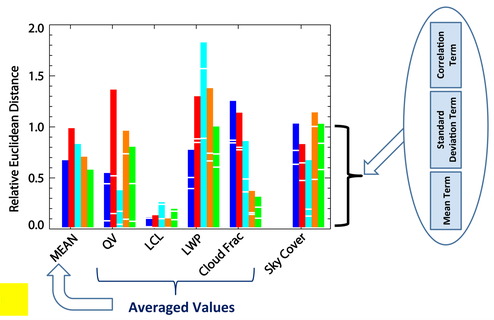


(f) Relative Euclidean Distance

Relative Euclidean Distance (RED) measures overall model performance in terms of first- and second-order statistics (Wu et al., 2012),

$$RED = \sqrt{\left[\frac{(\bar{M}-\bar{O})}{\bar{O}}\right]^2 + \left[\frac{(\sigma_M-\sigma_O)}{\sigma_O}\right]^2 + (1-r)^2}$$

where model performance (M) is compared to observations (O) in terms of the relative mean (term 1), standard deviation (term 2), and correlation coefficient (term 3). *RED*=0 for perfect agreement and model performance degrades as *RED* increases



This is work in progress -- Let us know if you have other suggestions!

References

LASSO implementation plan: http://www.arm.gov/publications/programdocs/doe-sc-arm-15-039.pdf

Taylor, K. E. (2001), Summarizing multiple aspects of model performance in a single diagram, *J. Geophys. Res.*, 106, 7183–7192, doi:10.1029/2000JD900719.

Wu, W., Y. Liu, and A. K. Betts (2012), Observationally based evaluation of NWP reanalyses in modeling cloud properties over the Southern Great Plains, *J. Geophys. Res.*, 117, D12202, doi:10.1029/2011JD016971.

To be included in LASSO project email updates, sign up for the LASSO Information e-mail list at http://eepurl.com/bCS8s5

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